Rec'd PCT/PTO 28 NOV 1997

FORM PTO-1390 (REV 10-96) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: 70558-2/8240

U S APPLICATION NO (If known, see 37 CFR 1 5): 08/973018

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/SE97/00885	27 May 1997	29 May 1997

TITLE OF INVENTION A HYDRO-GENERATOR PLANT

APPLICANT(S) FOR DO/EO/US LEIJON, Mats et al. [SEE ATTACHMENT A]

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☐ This is a **FIRST** submission of items concerning a filing under 35 U S.C. 371
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This express request to begin national examination procedures (35 U S C 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S C 371(b) and PCT Articles 22 and 39(1).
4. ☐ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date
5. ☐ A copy of the International Application as filed (35 U.S C. 371(c)(2))
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included
13. ☒ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information:
    Request
    PCT APP as filed.

U.S. APPLICATION NO (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER 70558-2/8240

17. [x] The following fees are submitted:

	CALCULATIONS	PTO USE ONLY
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):		
Search Report has been prepared by the EPO or JPO $930.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) $720.00		
No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) $790.00		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO $1070.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) $98.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 1070	
Surcharge of $130.00 for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	47 - 20 =	27	X $22.00	$ 594	
Independent claims	2 - 3 =	0	X $82.00	$ –	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ $270.00	$	
TOTAL OF ABOVE CALCULATIONS =				$	
Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also by filed (Note 37 CFR 1.9, 1.27, 1.28).				$	
SUBTOTAL =				$	
Processing fee of $130.00 for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f))				$	
TOTAL NATIONAL FEE =				$	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property				$	
TOTAL FEES ENCLOSED =				$ 1664	
				Amount to be: refunded	$
				charged	$

a. [X] A check in the amount of $ 1664 to cover the above fees is enclosed.

b. [ ] Please charge my Deposit Account No. ______________ in the amount of $______________ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 23-0576. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO

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SIGNATURE

John P. DeLuca
NAME

25,505
REGISTRATION NUMBER

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70558-2/8240

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	)	PATENT
Mats LEIJON et al.	)	Group: Unknown
Serial No: To be assigned	)	
New appln. based on PCT/SE97/00885	)	Examiner: Unknown
Filed: On Even Date	)	**ATTN: BOX PCT**
A HYDRO-GENERATOR PLANT	)	

* * * * * *

PRELIMINARY AMENDMENT

Washington, D.C.
NOV 28 1997

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Concurrently with the U.S. national filing of this application, please amend the present application as follows:

IN THE CLAIMS:

Please cancel claims 35 and 36 and amend claims 1-34 as follows:

Claim 1. (Amended) A hydrogenerator plant comprising at least one rotating electric machine [(100)] for high voltage, in which the generator is coupled to a turbine [(102)] via shaft means [(101)], said generator [(100)] comprising at least one

winding, [characterized in that] wherein the generator [(100)] is provided with solid insulation and in that each winding is arranged to be directly connected via coupling elements [(109)] to a transmission or distribution network [(110)] having a voltage of about between 20 and 800 kV[, preferably higher than 36 kV].

Claim 2 (Amended), line 1, delete "characterized in";

Line 2, delete "that" and insert --wherein--.

Claim 3. (Amended) A plant as claimed in [either of claims] claim 1 [or 2], [characterized in that] wherein the generator comprises a magnetic circuit with a magnetic core.

Claim 4 (Amended), line 1, delete "characterized in";

Line 2, delete "that" and insert --wherein--.

Claim 5. (Amended) A plant as claimed in [any of claims] claim 1[-4], [characterized in that] wherein the solid insulation is built up of a cable [(6)] intended for high voltage comprising one or more current-carrying conductors [(31)] surrounded by at least two semiconducting layers [(32, 34)] and intermediate insulating layers [(33)] of solid insulation.

Claim 6. (Amended) A plant as claimed in claim 5, [characterized in that] wherein the innermost semiconducting layer [(32)] is at substantially the same potential as the conductor(s) [(31)].

Claim 7. (Amended) A plant as claimed in [either] claim 5 [or claim 6], [characterized in that] wherein one of the outer semiconducting layers [(34)] is

arranged to form essentially an equipotential surface surrounding the conductor(s) [(31)].

Claim 8 (Amended), line 1, delete "characterized in";

Line 2, delete "that" and insert --wherein--; delete "(34)".

Claim 9 (Amended), line 1, delete "characterized in";

Line 2, delete "that" and insert --wherein--.

Claim 10. (Amended) A plant as claimed in [any of claims 5-9, characterized in that] claim 5, wherein at least two of said layers have substantially the same coefficient of thermal expansion.

Claim 11. (Amended) A plant as claimed in [any of claims] claim 5[-7], [characterized in that] the current-carrying conductor comprises a plurality of strands, only a few of the strands being uninsulated from each other.

Claim 12. (Amended) A plant as claimed in [any of claims] claim 1[-11], [characterized in that] wherein the winding consists of a cable comprising one or more current-carrying conductors [(2)], each conductor consisting of a number of strands, an inner semiconducting layer [(3)] being arranged around each conductor, an insulating layer [(4)] of solid insulation being arranged around each inner semiconducting layer [(3)] and an outer semiconducting layer [(5)] being arranged around each insulating layer [(4)].

Claim 13 (Amended), line 1, delete "characterized in";

Line 2, delete "that" and insert --wherein--.

Claim 14. (Amended) A plant as claimed in [any of the preceding claims, characterized in that] claim 1, wherein its stator [(1)] is cooled at earth potential by means of a flow of gas and/or liquid.

Claim 15. (Amended) A plant as claimed in [any of the preceding claims, characterized in that] claim 1, wherein the outermost semi-conductor layer [(34)] is connected to earth potential.

Claim 16. (Amended) A plant as claimed in [any of the preceding claims, characterized in that] claim 1, wherein the rotor [(2)] is inductively connected to the high voltage.

Claim 17 (Amended), line 1, delete "characterized in";

Line 2, delete "that" and insert --wherein--; delete "(2)".

Claim 18 (Amended), line 1, delete "characterized in";

Line 2, delete "that" and insert --wherein--.

Claim 19 (Amended), line 1, delete "characterized in";

Line 2, delete "that" and insert --wherein--.

Claim 20. (Amended) A plant as claimed in [claims] claim 18 [or claim 19], [characterized in that] wherein the stator has concentrated winding and that coils in the winding have a coil span equal to the pole pitch.

Claim 21. (Amended) A plant as claimed in claim 18 [or claim 19, characterized in that] wherein the coils in the stator winding are distributed and have a coil span different from the pole pitch.

Claim 22. (Amended) A plant as claimed in [any of claims] claim 5[-21], [characterized in that] the cables [(6)] with solid insulation have a conductor area of about between 40 and 3000 mm^2 and have an outer cable diameter of about between 20 and 250 mm.

Claim 23. (Amended) A plant as claimed in claim 22, [characterized in that] wherein the cable [(6)] is cooled by gas or liquid inside the current-carrying conductors [(31)].

Claim 24. (Amended) A plant as claimed in [any of the preceding claims, characterized in that] claim 1, wherein the electric generator [(100)] is designed for high voltage and arranged to supply the out-going electric network [(110)] directly without any intermediate connection of a transformer.

Claim 25. (Amended) A plant as claimed in [any of the preceding claims, characterized in that] claim 1, [it comprises] comprising several generators, each of which lacks an individual step-up transformer, but which, via a system transformer common to the generators, is connected to the transmission or distribution network.

Claim 26. (Amended) A plant as claimed in claim 24, [characterized in that] wherein at least one generator [100] is earthed via an impedance [(103)].

Claim 27 (Amended), line 1, delete "characterized in";

Line 2, delete "that" and insert wherein; delete "(100)".

Claim 28. (Amended) A plant as claimed in [any of claims] claim 24[-27], [characterized in that] wherein it is designed to be driven [alternatively] as at least one of a pump and turbine station, the electric machine [(100)] being arranged to function as at least one of a motor driven directly from the electric power network [(110) or] and as generator generating voltage for the electric power network.

Claim 29 (Amended), line 1, delete "characterized in";

Line 2, delete "that" and insert --wherein--.

Claim 30. (Amended) A plant as claimed in claim 29, [characterized in that] wherein one of said voltage levels is arranged to generate auxiliary power and that the auxiliary power is arranged to be generated from a separate winding [(119; 113)] in the generator [(100)].

Claim 31. (Amended) A plant as claimed in [any of claims] claim 1[-30, characterized in that] , wherein all components are earthed to the same earth system.

Claim 32. (Amended) A plant as claimed in [any of the preceding claims] claim 1, [characterized in that] wherein the winding of the generator is arranged for self-regulating field control and lacks auxiliary means for control of the field.

Claim 33. (Amended) Procedure for constructing a plant as claimed in [any of claims 1-32, characterized in that] claim 1, wherein the stator of the generator is delivered in parts to the plant site, said parts comprising separate stator laminations

and/or combined stacks of stator laminations, after which said parts are assembled on site, and in that both threading of the winding and any splicing required are performed on site.

Claim 34. (Amended) An electric generator [(100)] for high voltage included in a hydro-generator plant in which the generator is coupled to a turbine [(102)] via shaft means [(101)], said generator [(100)] comprising at least one winding, [characterized in that] the generator [(100)] is provided with solid insulation and in that each winding is arranged to be directly connected via coupling elements [(109)] to a transmission or distribution network [(110)] having a voltage of between <u>about</u> 20 and 800 kV[, preferably higher than 36 kV].

Add new claims 37-49 as follows:

--37. A hydrogenerator plant including a rotating high voltage electric machine comprising a stator; a rotor and a winding, wherein said winding comprises a cable including at least one current-carrying conductor and a magnetically permeable, electric field confining cover surrounding the conductor, said cable forming at least one uninterrupted turn in the corresponding winding of said machine.

38. The hydrogenerator plant of claim 37, wherein the cover comprises an insulating layer surrounding the conductor and an outer layer surrounding the insulating layer, said outer layer having a conductivity sufficient to establish an equipotential surface around the conductor.

39. The hydrogenerator plant of claim 37, wherein the cover comprises an inner layer surrounding the conductor and being in electrical contact therewith; an insulating layer surrounding the inner layer and an outer layer surrounding the insulating layer.

40. The hydrogenerator plant of claim 39, wherein the inner and outer layers have semiconducting properties.

41. The hydrogenerator plant of claim 37, wherein the cover is formed of a plurality of layers including an insulating layer and wherein said plurality of layers are substantially void free.

42. The hydrogenerator plant of claim 37, wherein the cover is in electrical contact with the conductor.

43.

44. The hydrogenerator plant of claim 42, wherein the layers of the cover have substantially the same temperature coefficient of expansion.

45. The hydrogenerator plant of claim 44, wherein the machine is operable at 100% overload for two hours.

46. The hydrogenerator plant of claim 37, wherein the cable is operable free of sensible end winding loss.

47. The hydrogenerator plant of claim 37, wherein the winding is operable free of partial discharge and field control.

48. The hydrogenerator plant of claim 37, wherein the winding comprises multiple uninterrupted turns.

49.--The hydrogenerator plant of claim 37, wherein the cable is flexible.--

If any multiple dependencies exist in the claims, it is respectfully requested that such dependencies be removed.

REMARKS

By this Preliminary Amendment claims 35 and 36 have been cancelled and claims 1-34 have been amended to better conform the claims with U.S. practice and to remove multiple dependencies therefrom. New claims set forth the invention in a different scope.

Respectfully submitted,

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JPD:jlh

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A HYDRO-GENERATOR PLANT

Technical field:

The present invention relates to a hydro-generator plant of the type described in the preamble to the claim and which is intended for connection to distribution or transmission networks, hereinafter called power networks. The invention also relates to an electric generator for high voltage in a hydro-generator plant intended for the above-mentioned purpose. The invention further relates to a procedure for assembling such a plant and the manufacture of such a generator.

Background art:

The magnetic circuits in electric generators usually comprise a laminated core, e.g. of sheet steel with a welded construction. To provide ventilation and cooling the core is often divided into stacks with radial and/or axial ventilation ducts. For larger machines the laminations are punched out in segments which are attached to the frame of the machine, the laminated core being held together by pressure fingers and pressure rings. The winding of the magnetic circuit is disposed in slots in the core, the slots generally having a cross section in the shape of a rectangle or trapezium.

In multi-phase electric generators the windings are made as either single or double layer windings. With single layer windings there is only one coil side per slot, whereas with double layer windings there are two coil sides per slot. By coil side is meant one or more conductors combined vertically or horizontally and provided with a common coil insulation, i.e. an insulation designed to withstand the rated voltage of the generator to earth.

Double-layer windings are generally made as diamond windings whereas single layer windings in the present context can be made as diamond or flat windings. Only one (possibly two) coil width exists in diamond windings whereas flat windings are made as concentric windings, i.e. with widely varying coil width. By coil width is meant the distance in arc dimension between two coil sides pertaining to the same coil.

Normally all large machines are made with double-layer winding and coils of the same size. Each coil is placed with one side in one layer and the other side in the other layer. This means that all coils cross each other in the coil end. If there are more than two

layers these crossings complicate the winding work and the coil end is less satisfactory.

It is considered that coils for rotating generators can be manufactured with good results within a voltage range of 3 - 20 kV.

It is also generally known that connection of a synchronous machine to a power network must be via a Δ/Y-connected or step-up transformer, since the voltage of the power network is generally higher than the voltage it has hitherto been able to achieve with the electric machine. Thus this transformer and the synchronous machine constitute integrated parts of a plant. The transformer entails an extra cost and also has the drawback that the total efficiency of the system is reduced. If, therefore, it were possible to manufacture electric generators for considerably higher voltages, the step-up transformer could be eliminated.

Although the dominant known technology for supplying current from a generator to a high-voltage network, a concept which in the present application applies to the level of 20 kV and upwards, preferably higher than 36 kV, is for a transformer to be inserted between the generator and the power network, it is already known to attempt to eliminate the transformer and generate the high voltage directly out to the power network at its voltage level. Such generators are described, for instance, in US-A-4 429 244, US-A-4 164 672 and US-A-3 743 867.

However, the machine designs according to the above publications do not permit optimal utilization of the electromagnetic material in the stator.

Description of the invention:

The object of the invention is thus to provide an electric generator which can be used in a hydro-generator plant for such high voltage that the above-mentioned Δ/Y-connected step-up transformer can be omitted, i.e. a plant in which the electric generators are intended for considerably high voltages than conventional machines of corresponding type, in order to be able to execute direct connection to power networks at all types of high voltage.

This object has been achieved according to the invention in that a plant of the type described in the preamble to claim 1 is given the special features defined in the characterizing part of this claim, in that a generator of the type described in the preamble to claim 34 is given the special features defined in the characterizing part

of this claim, and in that a procedure of the type described in the preamble to claims 33 and 36 includes the special measures defined in the characterizing parts of respective claims.

Thanks to the solid insulation in combination with the other features defined, the network can be supplied without the use of an intermediate step-up transformer even at network voltages considerably in excess of 36 kV.

The fact that the solid insulation enables the windings to be arranged for direct connection to the high-voltage network, thus eliminating the step-up transformer, offers great advantages over known technology.

The elimination of the transformer per se entails great savings, for instance, and the absence of the transformer also results in several other simplifications and thus savings.

A plant of this type is often arranged in a rock chamber where, with conventional technology, the transformer is arranged either in direct connection with the generator in the rock chamber or above ground at a distance of several hundred metres and connected to the generator by a busbar system. Compared with the first alternative, elimination of the transformer enables the volume of the rock chamber to be greatly reduced. The fire risk entailed with an oil-insulated transformer is also eliminated therefore reducing the necessity for extensive fire-safety precautions such as special evacuation routes for personnel.

In the alternative in which the transformer is placed above ground the busbar system is more extended due to the longer distance between the generator and the transformer. Since the current in the busbars (normally with aluminium conductors) is considerable, in the order of 10-20 kA, the power losses are large. Moreover, busbar systems introduce a risk for 2- and 3-phase faults during which the currents are considerable.

With the present invention two major objectives are achieved:
- The losses in the busrun are reduced due to the high voltage.
- The risk for 2- and 3-phase failures is considerably reduced due to the use of insulated HV cables.

The reduction in the number of electrical components achieved with the invention therefore means that the corresponding safety equipment can be omitted.

Furthermore, the rock chamber need not be blasted to allow laying of the busbar system, which entails a saving in rock chamber space of several thousand cubic metres.

The plant according to the invention also enables several connections with different voltage levels to be arranged, i.e. the invention can be used for all auxiliary power in the power station.

In all, the advantages mentioned above entail radically improved total economy for the plant. The plant cost, typically in the order of some hundred million SEK, is reduced by 30-50 %. Operating economy is improved both by less need for maintenance and by an increase in the degree of efficiency by 1-1.5 %. For an operating time of 8000 h/year, an output level corresponding to 150 MVA, a kWh price of SEK 0.20 and a useful service life of 30 years the gain would be approximately SEK 75 - 100 million per generator.

In a particularly preferred embodiment of the plant and generator respectively, the solid insulation system comprises at least two layers, each layer constituting essentially an equipotential surface, and also intermediate solid insulation therebetween, at least one of the layers having substantially the same coefficient of thermal expansion as the solid insulation.

This embodiment constitutes an expedient embodiment of the solid insulation that in an optimal manner enables the windings to be directly connected to the high-voltage network and where harmonization of the coefficients of thermal expansion eliminates the risk of defects, cracks or the like upon thermal movement in the winding.

It should be evident that the windings and the insulating layers are flexible so that they can be bent.

It should also be pointed out that the plant according to the invention can be constructed using either horizontal or vertical generators, which may be of either underground or aboveground type.

The above and other preferred embodiments of the invention are defined in the dependent claims.

The major and essential difference between known technology and the embodiment according to the invention is thus that this is achieved with a magnetic circuit included in an electric generator which is arranged to be directly connected via only breakers and isolators to a high supply voltage in the vicinity of between 20 and 800 kV, preferably higher than 36 kV. The magnetic circuit thus comprises

a laminated core having at least one winding consisting of a threaded cable with one or more permanently insulated conductors having a semiconducting layer both at the conductor and outside the insulation, the outer semiconducting layer being connected to earth potential.

To solve the problems arising with direct connection of electric machines to all types of high-voltage power networks, the generator in the plant according to the invention has a number of features as mentioned above, which differ distinctly from known technology. Additional features and further embodiments are defined in the dependent claims and are discussed in the following.

Such features mentioned above and other essential characteristics of the generator and thus of the hydro-generator plant according to the invention include the following:

- The winding of the magnetic circuit is produced from a cable having one or more permanently insulated conductors with a semiconducting layer at both conductor and sheath. Some typical conductors of this type are PEX cable or a cable with EP rubber insulation which, however, for the present purpose are further developed both as regards the strands in the conductor and the nature of the outer sheath.

- Cables with circular cross section are preferred, but cables with some other cross section may be used in order to obtain better packing density, for instance.

- Such a cable allows the laminated core to be designed according to the invention in a new and optimal way as regards slots and teeth.

- The winding is preferably manufactured with insulation in steps for best utilization of the laminated core.

- The winding is preferably manufactured as a multi-layered, concentric cable winding, thus enabling the number of coil-end intersections to be reduced.

- The slot design is suited to the cross section of the winding cable so that the slots are in the form of a number of cylindrical openings running axially and/or radially outside each other and having an open waist running between the layers of the stator winding.

- The design of the slots is adjusted to the relevant cable cross section and to the stepped insulation of the winding. The

stepped insulation allows the magnetic core to have substantially constant tooth width, irrespective of the radial extension.

- The above-mentioned further development as regards the strands entails the winding conductors consisting of a number of impacted strata/layers, i.e. insulated strands that from the point of view of an electric machine, are not necessarily correctly transposed, uninsulated and/or insulated from each other.

- The above-mentioned further development as regards the outer sheath entails that at suitable points along the length of the conductor, the outer sheath is cut off, each cut partial length being connected directly to earth potential.

The use of a cable of the type described above allows the entire length of the outer sheath of the winding, as well as other parts of the plant, to be kept at earth potential. An important advantage is that the electric field is close to zero within the coil-end region outside the outer semiconducting layer. With earth potential on the outer sheath the electric field need not be controlled. This means that no field concentrations will occur either in the core, in the coil-end regions or in the transition between them.

The mixture of insulated and/or uninsulated impacted strands, or transposed strands, results in low stray losses.

The cable for high voltage used in the magnetic circuit winding is constructed of an inner core/conductor with a plurality of strands, at least two semiconducting layers, the innermost being surrounded by an insulating layer, which is in turn surrounded by an outer semiconducting layer having an outer diameter in the order of 20-200 mm and a conductor area in the order of 40-3000 mm^2.

The solid insulation in a generator according to the invention also offers great advantages when constructing a hydro-generator plant. The absence of wet insulation means that the stator of the generator need not be completed at the factory but can instead be delivered in parts and assembled on site. A stator of the size under consideration here is large and heavy which has entailed transport problems with conventional designs where the roads must be reinforced and dimensioned for the vast weight. This problem is eliminated since the stator for a generator can be delivered in parts.

The invention thus also relates to the procedures as defined in claims 30 and 33, where this possibility is exploited when building

a hydro-generator plant and manufacturing a generator, respectively.

Brief description of the drawings:

The invention will be described in more detail in the following detailed description of a preferred embodiment of constructing the magnetic circuit of the electric generator in the hydro-generator plant, with reference to the accompanying drawings in which

Figure 1 shows a schematic axial end view of a sector of the stator in an electric generator in the hydro-generator plant according to the invention,

Figure 2 shows an end view, partially stripped, of a cable used in the winding of the stator according to Figure 1,

Figure 3 shows a simplified view, partially in section, of a hydro-generator arrangement according to the invention,

Figure 4 shows a circuit diagram for the hydro-generator plant according to the invention,

Figure 5 shows a section through a conventional hydro-generator plant.

Figure 6 is a diagram showing a traditional solution for auxiliary power for a hydro plant, and

Figure 7 is a diagram showing generators with build-in windings for generation of auxiliary power according to the invention.

Description of a preferred embodiment:

In order to understand certain aspects of the advantages of the invention, reference is made initially to Figure 5 showing an example of a conventional hydro-generator plant. This is of a type with the transformer hall 501 situated some way from the generator hall 502, the latter being in the form of a rock chamber housing the generator 503. The generator 503 is connected to the transformer in the transformer hall 501 via a busbar system 505 arranged in a tunnel system 504 several hundred metres long. A plant according to the invention entirely eliminates the part to the right of the line A-A in Figure 5, while substantially the same dimensions are retained in the generator hall 502. A conventional plant without the transformer situated above ground as shown in Figure 5 would instead require a considerably larger generator hall

502 to allow space for the transformer and its auxiliary and safety equipment.

The rotor 2 of the generator is also indicated in the schematic axial view through a sector of the stator 1 according to Figure 1, pertaining to the generator 100 (Figure 3) included in the hydro-generator plant. The stator 1 is composed in conventional manner of a laminated core. Figure 1 shows a sector of the generator corresponding to one pole pitch. From a yoke part 3 of the core situated radially outermost, a number of teeth 4 extend radially in towards the rotor 2 and are separated by slots 5 in which the stator winding is arranged. Cables 6 forming this stator winding, are high-voltage cables which may be of substantially the same type as those used for power distribution, i.e. PEX cables. PEX = crosslinked polyethylene (XLPE). One difference is that the outer, mechanically-protective sheath, and the metal screen normally surrounding such power distribution cables are eliminated so that the cable for the present application comprises only the conductor and at least one semiconducting layer on each side of an insulating layer. Thus, the semiconducting layer which is sensitive to mechanical damage lies naked on the surface of the cable.

The cables 6 are illustrated schematically in Figure 1, only the conducting central part of each cable part or coil side being drawn in. As can be seen, each slot 5 has varying cross section with alternating wide parts 7 and narrow parts 8. The wide parts 7 are substantially circular and surround the cabling, the waist parts between these forming narrow parts 8. The waist parts serve to radially fix the position of each cable. The cross section of the slot 5 also narrows radially inwards. This is because the voltage on the cable parts is lower the closer to the radially inner part of the stator 1 they are situated. Slimmer cabling can therefore be used there, whereas coarser cabling is necessary further out. In the example illustrated cables of three different dimensions are used, arranged in three correspondingly dimensioned sections 51, 52, 53 of slots 5. An auxiliary power winding 9 is arranged furthest out in the slot 5.

Figure 2 shows a step-wise stripped end view of a high-voltage cable for use in an electric machine according to the present invention. The high-voltage cable 6 comprises one or more conductors 31, each of which comprises a number of strands 36 which together give a circular cross section of copper (Cu), for instance. These conductors 31 are arranged in the middle of the high-voltage cable 6 and in the shown embodiment each is surrounded

by a part insulation 35. However, it is feasible for the part insulation 35 to be omitted on one of the conductors 31. In the present embodiment of the invention the conductors 31 are together surrounded by a first semiconducting layer 32. Around this first semiconducting layer 32 is an insulating layer 33, e.g. PEX insulation, which is in turn surrounded by a second semiconducting layer 34. Thus the concept "high-voltage cable" in this application need not include any metallic screen or outer sheath of the type that normal surrounds such a cable for power distribution.

A hydro-generator with a magnetic circuit of the type described above is shown in Figure 3 where the generator 100 is driven by a water turbine 102 via a common shaft 101.

The stator 1 of the generator 100 thus carries the stator windings 10 which are built up of the cable 6 described above. The cable 6 is unscreened and changes to a screened cable 11 at the cable splicing 9.

With a hydro-generator 100 according to the invention it is thus possible to generate extremely high electric voltages of up to approximately 800 kV. It is thus possible to electrically connect the hydro-generator 100 directly to a distribution or transmission network 110 with an intermediate step-up transformer or similar electric machine as is generally the case in conventional plants where equivalent generators are able at most to generate voltages of up of 25-30 kV.

Figure 4 illustrates a hydro-generator plant according to the present invention. In conventional manner, the generator 100 has an excitation winding 112 and one (or more) auxiliary power winding(s) 113. In the shown embodiment of the plant according to the invention the generator 100 is earthed via an impedance 103.

It can also be seen from Figure 4 that the generator 100 is electrically connected via the cable splicing 9 to the screened cable 11 (see also Figure 3). The cable 11 is provided with current transformers 104 in conventional manner, and terminates at 105. After this point 105 the electric plant in the shown embodiment continues with busbars 106 having branches with voltage transformers 107 and surge arresters 108. However, the main electric supply takes place via the busbars 106 directly to the distribution or transmission network 110 via isolator 109 and circuit-breaker 111.

A hydro-generator plant according to the invention is designed for operation either to generate electric voltage for the power network

as described above, or as a pump plant, i.e. to be driven from the electric power network 110. The generator 100 then operates as a motor to drive the turbine 102 as a pump.

Thus, with the hydro-generator 100, no intermediate coupling of a step-up transformer is required. With the hydro-generator plant according to the present invention, therefore, several transformer and breaker units previously necessary are eliminated, which is obviously an advantage - not least from the aspects of cost and operating reliability.

Although the hydro-generator and the plant in which this generator is included have been described and illustrated in connection with an embodiment by way of example, it should be obvious to one skilled in that art that several modifications are possible without departing from the inventive concept. The generator may be earthed directly, for instance, without any impedance. The auxiliary windings can be omitted, as also other components shown. Although the invention has been exemplified with a three-phase plant, the number of phases may be more or less.

CLAIMS

1. A hydro-generator plant comprising at least one rotating electric machine (100) for high voltage, in which the generator is coupled to a turbine (102) via shaft means (101), said generator (100) comprising at least one winding, characterized in that the generator (100) is provided with solid insulation and in that each winding is arranged to be directly connected via coupling elements (109) to a transmission or distribution network (110) having a voltage of between 20 and 800 kV, preferably higher than 36 kV.

2. A plant as claimed in claim 1, characterized in that the winding includes an insulation system comprising at least two semiconducting layers, each layer constituting essentially an equipotential surface, and also intermediate solid insulation wherein at least one of the layers has substantially the same coefficient of thermal expansion as the solid insulation.

3. A plant as claimed in either of claims 1 or 2, characterized in that the generator comprises a magnetic circuit with a magnetic core.

4. A plant as claimed in claim 3, characterized in that the flux paths in the core of the magnetic circuit consist of laminated sheet and/or cast iron and/or powder-based iron, and/or rough forge iron.

5. A plant as claimed in any of claims 1-4, characterized in that the solid insulation is built up of a cable (6) intended for high voltage comprising one or more current-carrying conductors (31) surrounded by at least two semiconducting layers (32, 34) and intermediate insulating layers (33) of solid insulation.

6. A plant as claimed in claim 5, characterized in that the innermost semiconducting layer (32) is at substantially the same potential as the conductor(s) (31).

7. A plant as claimed in either claim 5 or claim 6, characterized in that one of the outer semiconducting layers (34) is arranged to form essentially an equipotential surface surrounding the conductor(s) (31).

8. A plant as claimed in claim 7, characterized in that said outer semiconducting layer (34) is connected to a predefined potential.

9. A plant as claimed in claim 8, characterized in that the predefined potential is earth potential.

10. A plant as claimed in any of claims 5-9, characterized in that at least two of said layers have substantially the same coefficient of thermal expansion.

11. A plant as claimed in any of claims 5-7, characterized in that the current-carrying conductor comprises a plurality of strands, only a few of the strands being uninsulated from each other.

12. A plant as claimed in any of claims 1-11, characterized in that the winding consists of a cable comprising one or more current-carrying conductors (2), each conductor consisting of a number of strands, an inner semiconducting layer (3) being arranged around each conductor, an insulating layer (4) of solid insulation being arranged around each inner semiconducting layer (3) and an outer semiconducting layer (5) being arranged around each insulating layer (4).

13. A plant as claimed in claim 12, characterized in that the cable also comprises a metal screen and a sheath.

14. A plant as claimed in any of the preceding claims, characterized in that its stator (1) is cooled at earth potential by means of a flow of gas and/or liquid.

15. A plant as claimed in any of the preceding claims, characterized in that the outermost semi-conductor (34) is connected to earth potential.

16. A plant as claimed in any of the preceding claims, characterized in that the rotor (2) is inductively connected to the high voltage.

17. A plant as claimed in claim 16, characterized in that the rotor (2) is cylindrical in shape, has salient poles and also has a constant air gap.

18. A plant as claimed in claim 17, characterized in that the stator winding is carried out with integral slot winding.

19. A plant as claimed in claim 17, characterized in that the stator winding is carried out with fractional slot winding.

20. A plant as claimed in claim 18 or claim 19, characterized in that the stator has concentrated winding

and that coils in the winding have a coil span equal to the pole pitch.

21. A plant as claimed in claim 18 or claim 19, characterized in that the coils in the stator winding are distributed and have a coil span different from the pole pitch.

22. A plant as claimed in any of claims 5-21, characterized in that the cables (6) with solid insulation have a conductor area of between 40 and 3000 mm^2 and have an outer cable diameter of between 20 and 250 mm.

23. A plant as claimed in claim 22, characterized in that the cable (6) is cooled by gas or liquid inside the current-carrying conductors (31).

24. A plant as claimed in any of the preceding claims, characterized in that the electric generator (100) is designed for high voltage and arranged to supply the out-going electric network (110) directly without any intermediate connection of a transformer.

25. A plant as claimed in any of the preceding claims, characterized in that it comprises several generators, each of which lacks an individual step-up transformer, but which, via a system transformer common to the generators, is connected to the transmission or distribution network.

26. A plant as claimed in claim 24, characterized in that at least one generator (100) is earthed via an impedance (103).

27. A plant as claimed in claim 24, characterized in that at least one generator (100) is directly earthed.

28. A plant as claimed in any of claims 24-27, characterized in that it is designed to be driven alternatively as pump and turbine station, the electric machine (100) being arranged to function as motor driven directly from the electric power network (110) or as generator generating voltage for the electric power network.

29. A plant as claimed claim 24, characterized in that the generator is arranged to generate power to various voltage levels.

30. A plant as claimed claim 29, characterized in that one of said voltage levels is arranged to generate auxiliary power and that the auxiliary power is arranged to be generated from a separate winding (119;113) in the generator (100).

31. A plant as claimed in any of claims 1-30, characterized in that all components are earthed to the same earth system.

32. A plant as claimed in any of the preceding claims, characterized in that the winding of the generator is arranged for self-regulating field control and lacks auxiliary means for control of the field.

33. Procedure for constructing a plant as claimed in any of claims 1-32, characterized in that the stator of the generator is delivered in parts to the plant site, said parts comprising separate stator laminations and/or combined stacks of stator laminations, after which said parts are assembled on site, and in that both threading of the winding and any splicing required are performed on site.

34. An electric generator (100) for high voltage included in a hydro-generator plant in which the generator is coupled to a turbine (102) via shaft means (101), said generator (100) comprising at least one winding, characterized in that the generator (100) is provided with solid insulation and in that each winding is arranged to be directly connected via coupling elements (109) to a transmission or distribution network (110) having a voltage of between 20 and 800 kV, preferably higher than 36 kV.

35. A generator as claimed in claim 34, characterized in that it includes the features defined for the generator included in the plant as claimed in any of claims 2-32.

36. A procedure for manufacturing a generator as claimed in claim 34 or 35, characterized in that said manufacture includes the measures for assembly of the generator which are defined in claim 33.

ABSTRACT

The magnetic circuit of a generator in a hydro-generator plant is arranged to directly supply a high supply voltage of 20 - 800 kV, preferably higher than 36 kV. The generator is provided with solid insulation and its winding includes a cable (6) comprising one or more current-carrying conductors (31) with a number of strands (36) surrounded by at least one outer and one inner semiconducting layer (34, 32) and intermediate insulating layers (33). The outer semiconducting layer (34) is at earth potential. The stator winding may be produced with full or fractional slot winding, the phases of the winding being Y-connected. The Y-point may be insulated and protected from over-voltage by means of surge arresters, or else the Y-point may be earthed via a suppression filter. The invention also relates to a hydro-generator plant, a generator included in the plant and a procedure for building such a plant.

(Figure 2.)

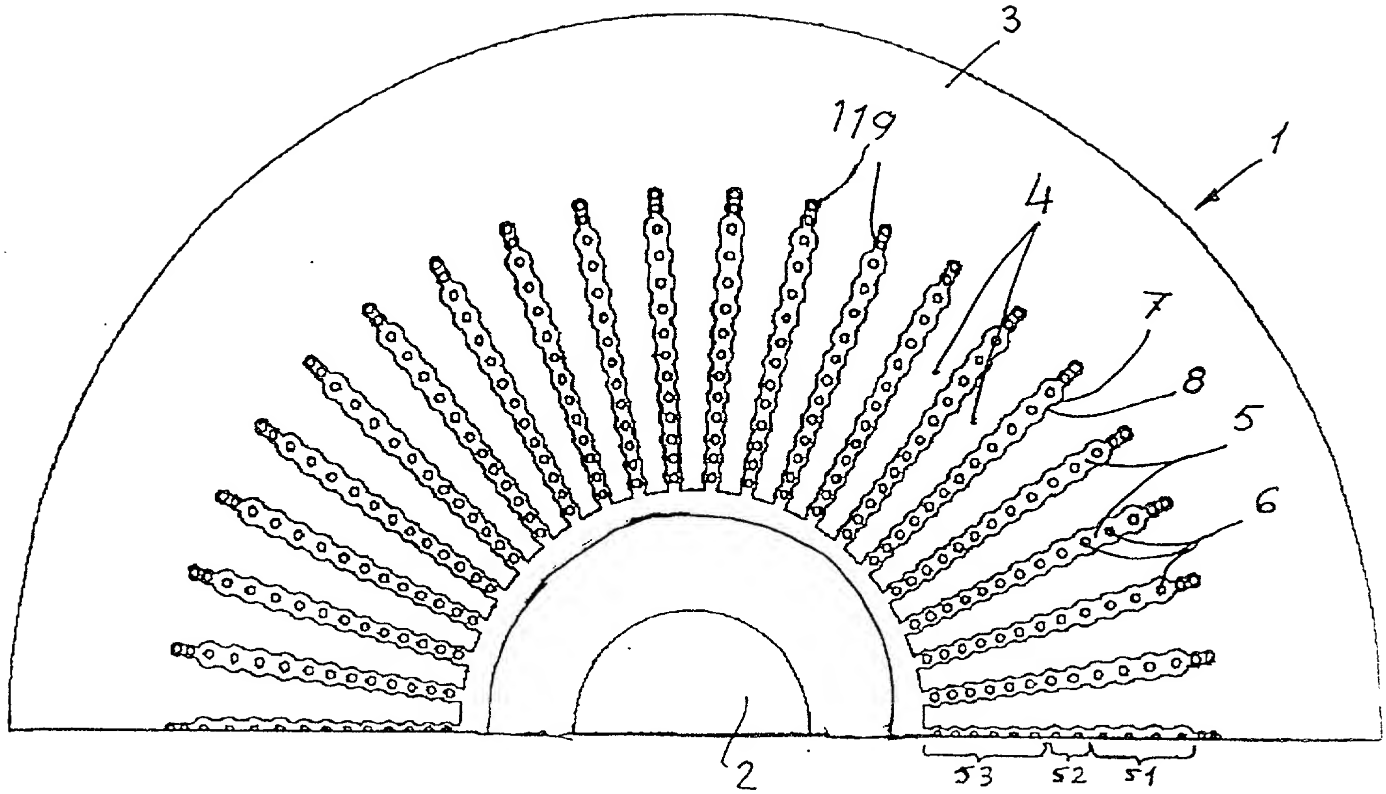

Fig. 1

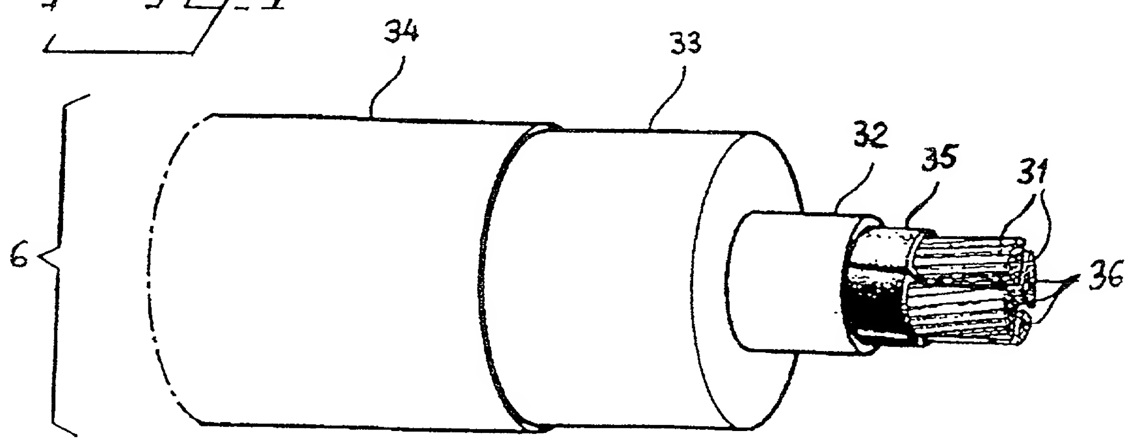

Fig. 2

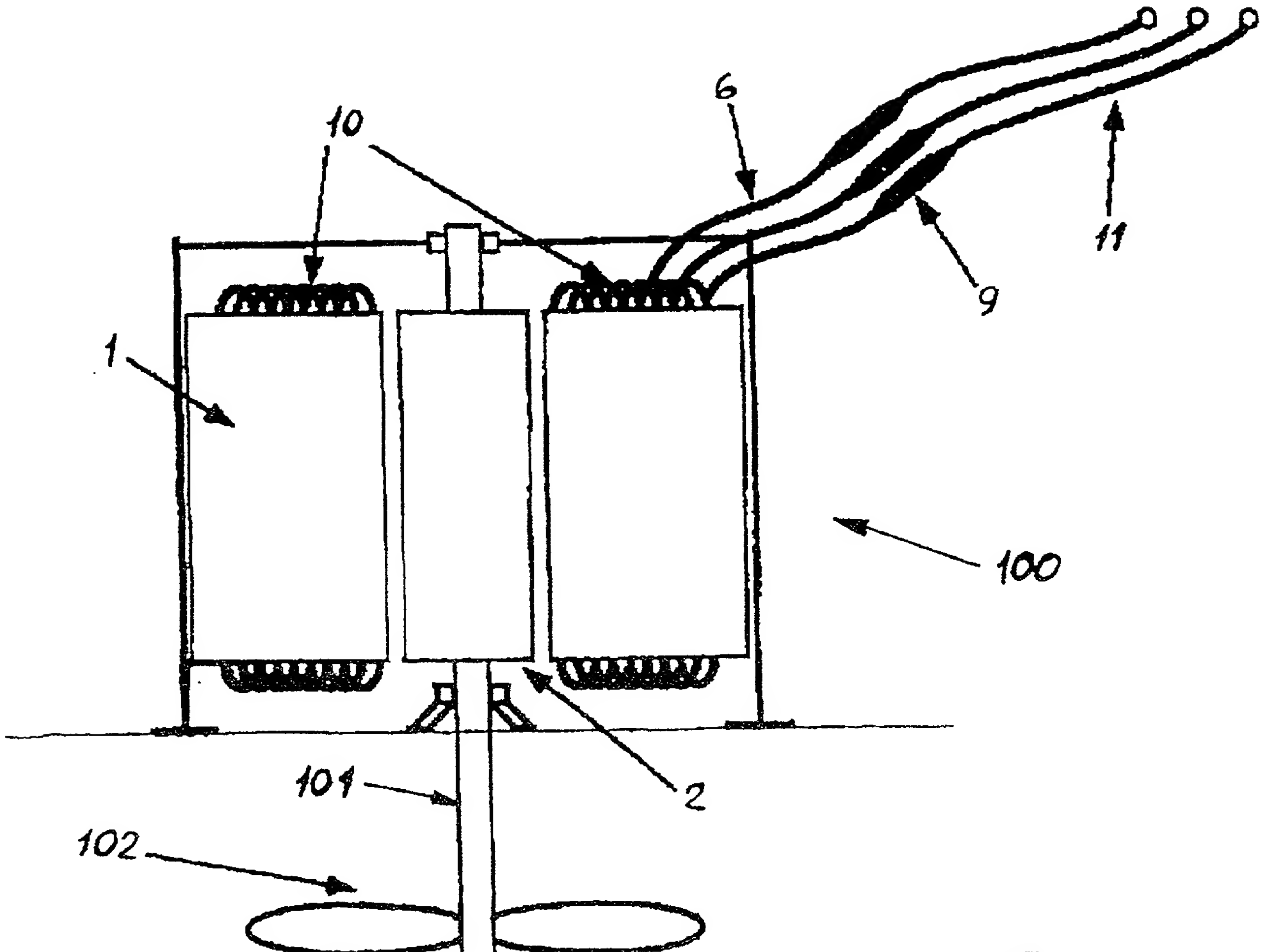

Fig. 3

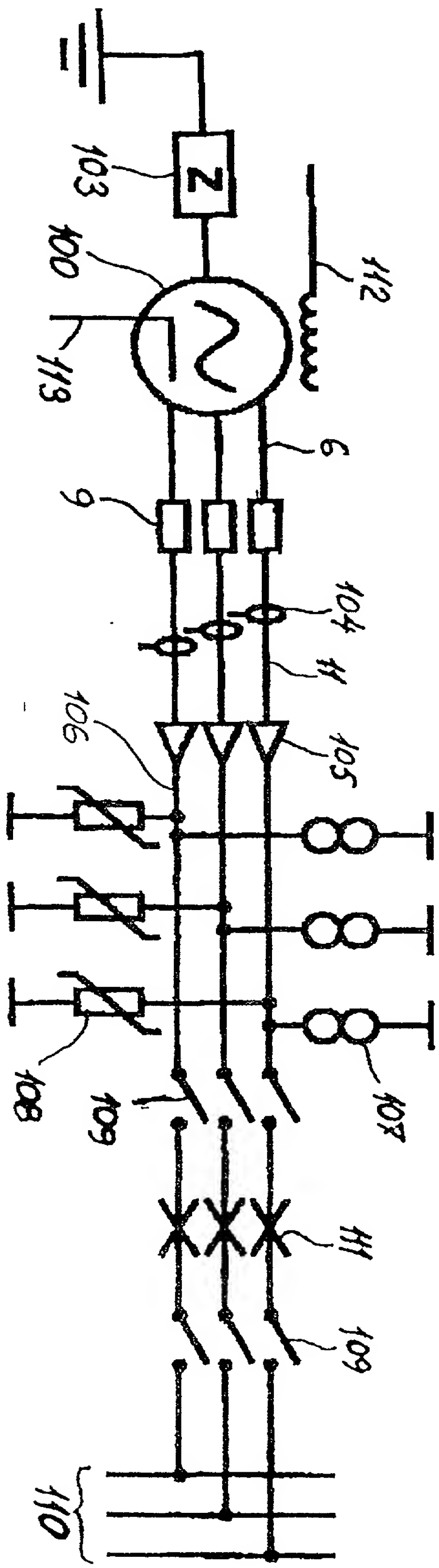

Fig. 4

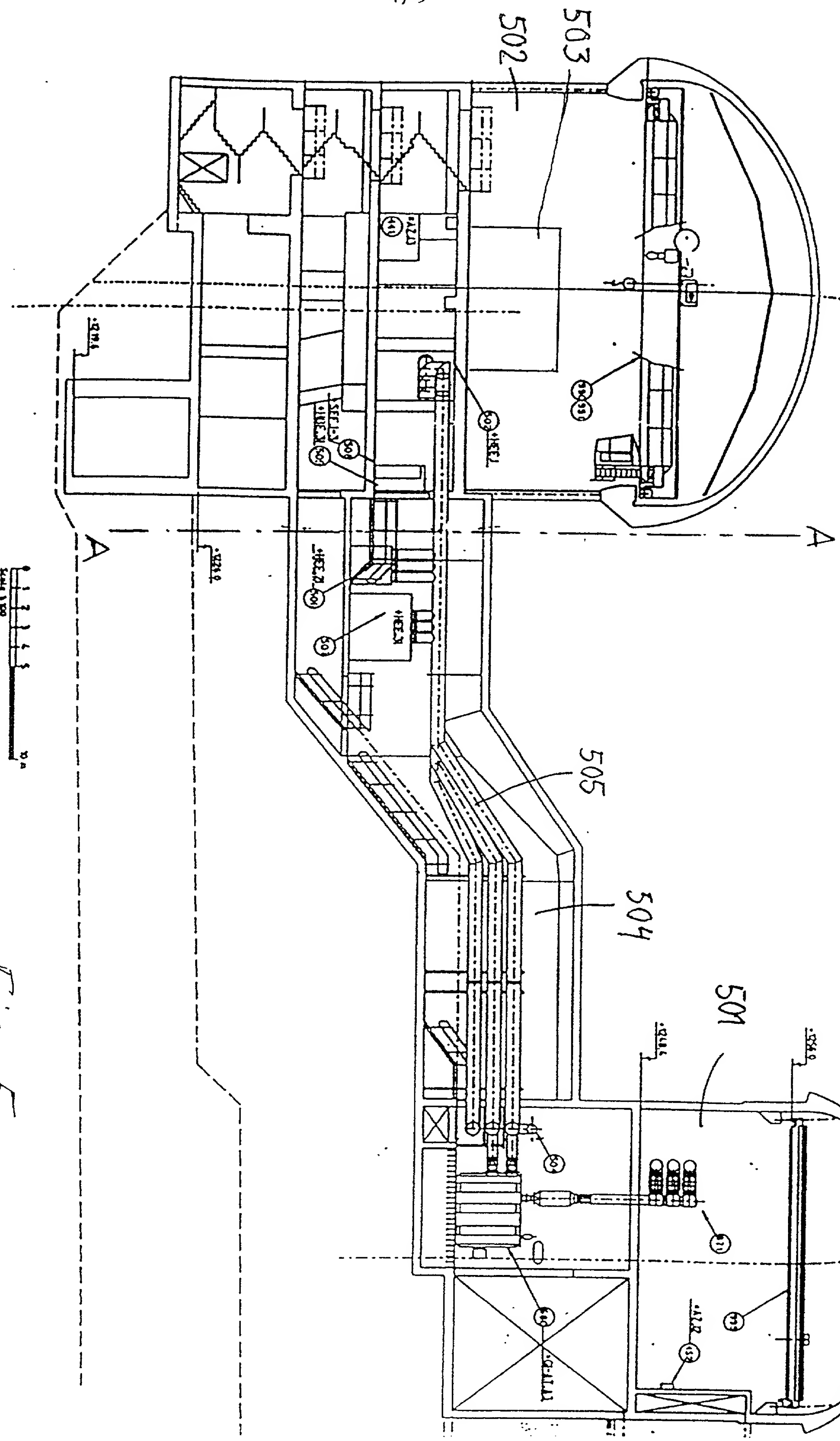

Fig. 5

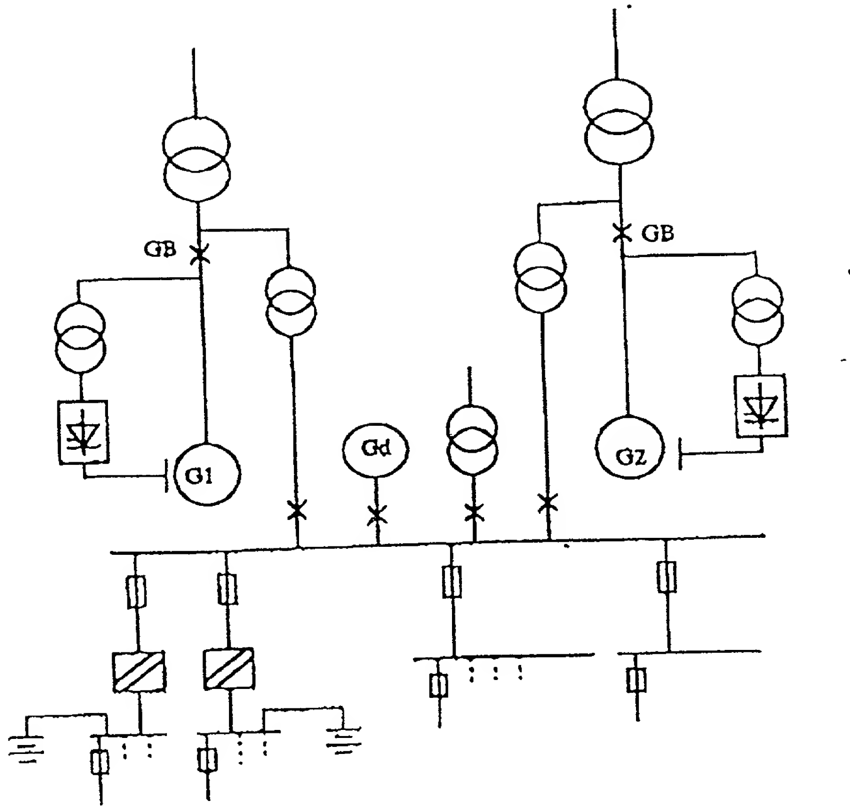

Fig 6

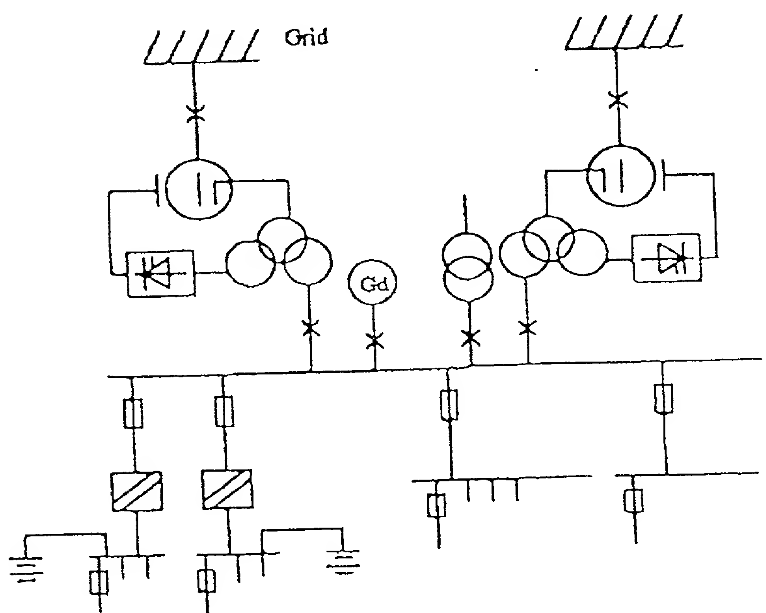

Fig 7

COMBINED DECLARATION AND POWER OF ATTORNEY FOR UTILITY PATENT APPLICATION (Includes PCT)	Attorney Docket No. 70558-2/8240

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name; that

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural inventors are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

A HYDRO-GENERATOR PLANT

the specification of which (check one)

[ ] is attached hereto.

[ ] was filed on ______________ as Application Serial No. ______________.

[X] was filed as PCT international application no. PCT/SE97/00885 on 27 May 1997 and was amended under PCT Article 19 on ______________ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I do not know and do not believe the claimed invention was ever known or used in the United States of America before my or our invention thereof, or patented or described in any printed publication in any country before my or our invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months prior to this application.

I hereby claim priority benefits under Title 35, United States Code §119 of any application(s) for patent or inventor's certificate listed below and have also identified below any application for patent or inventor's certificate having a filing date before that of the application(s) on which priority is claimed:

Prior Application(s)

			Priority Claimed	
9602079-7	Sweden	29 May 1996	[x]	[ ]
(Number)	(Country)	Day/Month/Year Filed	Yes	No

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or PCT international application(s) designating the United States of America listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

Attorney Docket No. 70558-2/8240

Application Serial No.	Filing Date	Status (patented, pending, abandoned)
Application Serial No.	Filing Date	Status (patented, pending, abandoned)

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: Robert J. Lasker, Reg. No. 22,785; Lawrence R. Radanovic, Reg. No. 23,077; Richard H. Tushin, Reg. No. 27,297; Donald N. Huff, Reg. No. 27,561; and John P. DeLuca, Reg. No. 25,505. Direct all telephone calls to telephone no. (202) 628-0088 and faxes to (202) 628-~~8034~~.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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